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Terrain Analytical Measures During Tactical Engagement Simulations

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This paper is based on a presentation on research accomplished in HumRRO Project COTEAM, "Combat Operations Training Effectiveness Analysis Model Applied to Rifle Squad and Platoon Evaluation." Engagement simulation has been found to be an effective method of training soldiers for combat. Soldiers trained in this form of simulated combat perform better than soldiers trained without the realistic casualty assessment techniques employed in engagement simulation.   In the military, the employment of terrain has long been known

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to have an effect on combat outcomes. To the extent that casualty location can be predicted for specific terrain, it should be possible to estimate process measures, such as the soundness of defensive position selection, of claymore mine placement, and of routes of advance. Given the need for process measures and the requirement that these measures be applied to engagement simulation training, the research addressed in this paper was conducted. Specifically, the objectives of the research were to predict the locations of casualties suffered by rifle squads in movement to contact missions on specific terrain, record the distances at which movement to contact units' casualties occurred, and to develop the procedures necessary to collect the required data.

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Terrain Analytical Measures During Tactical Engagement Simulations

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December 1981

PREFATORY NOTE

This Professional Paper is based on a presentation by
Mr. David L. Hannaman of HumRRO's Educational and
Training Systems Division at a seminar on Unit Performance
Measurement in October 1981. The seminar was sponsored
by the U.S. Army Research Institute for the Behavioral and
Social Sciences. Mr. Hannaman's paper was presented in a
session devoted to "Engagement Simulation in Unit Perform-
ance Measurement," and was based on research accomplished
in HumRRO Project COTEAM, "Combat Operations Training
Effectiveness Analysis Model Applied to Rifle Squad and
Platoon Evaluation." The Project Director for COTEAM was
Dr. Joseph A. Olmstead; the ARI Technical Monitor was
Dr. Robert Sulzen.

TERRAIN ANALYTICAL MEASURES DURING
TACTICAL ENGAGEMENT SIMULATION

Engagement simulation has been found to be an effective method of training soldiers for combat. Soldiers trained in this form of simulated combat perform better than soldiers trained without the realistic casualty assessment techniques employed in engagement simulation. The effectiveness measured thus far has centered on products or casualties suffered or inflicted. Products are useful in determining success or failure, but provide little information on what process was employed. In order to provide trainees or units with diagnostic information on how to improve performance, detailed information is needed about the process that produces the products.

In the military, the employment of terrain has long been known to have an effect on combat outcomes. To the extent that casualty location can be predicted for specific terrain, it should be possible to estimate process measures, such as the soundness of defensive position selection, of claymore mine placement, and of routes of advance.

Given the need for process measures and the requirement that these measures be applied to engagement simulation training, the research addressed in this paper was conducted. Specifically, the objectives of the research were to predict the locations of casualties suffered by rifle squads in movement to contact missions on specific terrain, record the distances at which movement to contact units' casualties occurred, and to develop the procedures necessary to collect the required data.

1

METHOD

This research was performed while the 1st Battalion, 3rd Infantry (The Old Guard) was conducting its Squad ARTEP (Army Training and Evaluation Program). This phase of the ARTEP consisted of a movement-to-contact mission for each of the fifty-four (54) rifle squads being evaluated. During the ARTEP period, three separate movement-to-contact missions were conducted per day, three days a week. Predictions of casualty locations were made for each of the three lanes used for movement-to-contact exercises.

LANES USED

Three lanes were used to conduct the movement-to-contact portion of the ARTEP. They were referred to as Alpha, Bravo and Charlie (A, B and C). Two lanes (Bravo and Charlie) were parallel, with a clearing separating them. This clearing served as the respective right and left flank boundaries. The other flank boundaries were marked at five-meter intervals with engineer tape attached to trees. Alpha lane was a "dog leg," with a road marking the right defensive boundary, and engineer tape marking the left boundary. Three ARTEP MILES (Multiple Integrated Laser Engagement System) exercises were conducted on the same lane. Each day a different lane was used. During the course of a week, nine exercises (three per lane) were conducted using engagement simulation procedures.

CONTROLLED VARIABLES

The Opposition Forces (OPFOR) for the movement-to-contact mission was comprised of a three-man team from the 1st Battalion, 3rd Infantry scout platoon. The OPFOR defended against an attacking squad that was being evaluated for the movement-to-contact phase of its ARTEP. Two claymore mines were placed at the main positions by the OPFOR and remained in the same locations for all exercises.

The main positions consisted of two foxholes which were perpendicular to the route of advance. These foxholes were chest-deep, with a parapet but no overhead cover, and were extensively camouflaged. One foxhole was designed to accommodate two men.

Directly in front of the main positions about 100 to 150 meters was an observation post (OP) position. It was manned by one member of the OPFOR and consisted of a foxhole of a design similar to that of the main positions. The occupant of the OP was instructed to withdraw directly back to the main positions after initial contact and before being decisively engaged. He was not permitted to fire while withdrawing. He then entered the two-man foxhole in the main positions. The OPFOR personnel were not permitted to move from their positions at any time with the exception of the OP withdrawal to the main position.

SQUAD STRENGTH AND SIMILARITIES

Squads ranged in strength from seven to ten men. All were armed in a similar fashion, with each rifleman carrying roughly 120 rounds of M16 rifle ammunition (at the individual's discretion). In addition, each man carried two hand grenades and, usually, there was

3

an M-60 machine gun with each squad. Due to jamming and other problems, the use of machine guns was not entirely consistent.

TERRAIN FACTORS

For each defensive position, three terrain factors were considered in predicting the location of casualties. These were: relief, vegetation and deadfall.

o   <u>Relief</u>. The terrain was slightly rolling with small gullies, depressions, and spill-offs intermittently located. Given a specific defensive position, these slight variations in elevation provided cover and concealment to personnel on the offense.

o   <u>Vegetation</u>. The vegetation was primarily coniferous, with pine trees averaging about 65 feet in height. There were about five to ten meters of space betweee trees. Concentratons of undergrowth were scattered about the lanes sufficiently to affect line-of-sight, detection, and maneuvering distances.

o   <u>Deadfall</u>. Deadfall was frequent and sometimes sufficient to be of aid to the offense.

FORECASTING LOCATIONS OF OFFENSIVE CASUALTIES

For each fixed defensive position, researchers identified a zone within which offense casualties were predicted to occur. The area and boundaries of each zone were determined by availability of line-of-sight from the defensive positions, taking into account the three terrain factors discussed above. Thus, offense casualties were predicted to occur where attacking personnel would be visible from

defensive positions because terrain factors provided minimal cover and concealment.

From each fixed defensive position, the zone within which offensive casualties should occur was outlined on a scale map (approximately 5/8 inch = 10 meters). This was accomplished by first marking trees on the lanes with numbers. Numbers were drawn on 8 x 8 inch white plastic cards and fixed to trees approximately every ten meters in rows along fixed compass headings. A matrix was thus established and points were plotted on a grid system, creating a scaled map upon which casualty zones could be drawn.

PLOTTING LOCATIONS OF ACTUAL CASUALTIES

When a casualty occurred during an exercise, location of the casualty was ascertained and plotted on the map by determining the number of the tree nearest to the individual and identifying the point on the map corresponding to the number of the tree. Each soldier had his own personnel number on the back of his helmet and this number was plotted on the map where he was hit. In this manner, not only would the map indicate the position of a casualty, but also, exactly who was a casualty at a given location.

A composite of casualty location maps for all squad movement-to-contact ARTEPS was then produced and the actual locations of offensive casualties were compared with predicted locations.

RESULTS

The degree to which the location of offense casualties were accurately predicted applying the aforementioned methodology to squad movement to contact ARTEPs will be discussed in this section. Here, the accuracy of predictions by individual lanes, individual positions, and overall prediction accuracy will be focused upon.

PREDICTING LOCATION OF CASUALTIES (MAIN POSITIONS COLLECTIVELY AND OP POSITION)

As discussed previously, the opposition force (OPFOR) for the squad movement-to-contact ARTEP was comprised of three men in three positions (one one-man observation post (OP) position and two main defensive positions (one one-man position and one two-man position). Each of these positions were fixed for each squad movement-to-contact mission. Three lanes (A, B and C) were used in which the same types of positions and OPFOR were employed. For each position, a zone was identified in which casualties were predicted to occur. Casualties occurring within the zones were accurately predicted. Those which occurred outside the zones were not predicted accurately.

The casualty location prediction data will be summarized in two ways. First, the accuracy of predictions for OP and main defensive positions within each lane will be presented and discussed. Second, the data will be summarized by lane and left and right flank main defensive positions.

Since each lane was comprised of three positions situated at two different locations, OP and main defensive positions were treated as

6

two distinct battle areas and predictions were made for each area. The accuracy of these predictions is summarized in Table 1.

Table 1

Location and Prediction of Casualties

	Number of Casualties						Percent Predicted		
	OP		Main		All Positions				
Lane	Total	Zone[1]	Total	Zone[1]	Total	Zone[1]	OP	Main	All Positions
A	26	21	105	79	131	100	81	75	76
B	20	16	125	96	145	112	80	77	77
C	17	13	128	97	145	110	76	76	76
Total	63	50	358	272	421	308	78	76	76

[1] Casualties within zone of prediction.

For all lanes, 76% of casualties occurred where predicted. Between the lanes, accuracy of prediction was quite similar (76, 77, and 76%). Furthermore, accuracy of prediction for OP and main positions was quite similar (78 and 76%).

Figures 1, 2 and 3 illustrate the predicted and actual location of offense casualties that occurred on Lanes A, B and C. Each figure is comprised of two diagrams. One shows the predicted and actual location of offense casualties for the OP position, and the other shows predicted and actual location of offense casualties at the main positions. The shaded area in each diagram represents the prediction zone for offense casualties. Dots indicate the location of offense casualties caused by M16 fire, open circles are locations of casualties caused by grenades, and open triangles indicate the location of offense casualties caused by claymore mines.
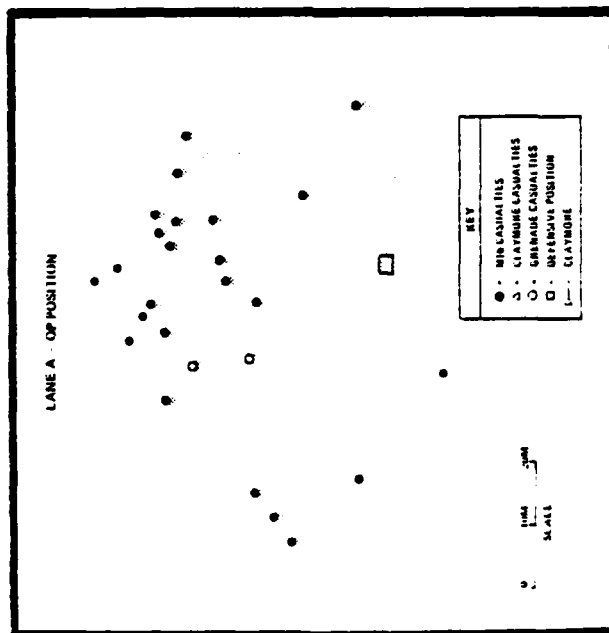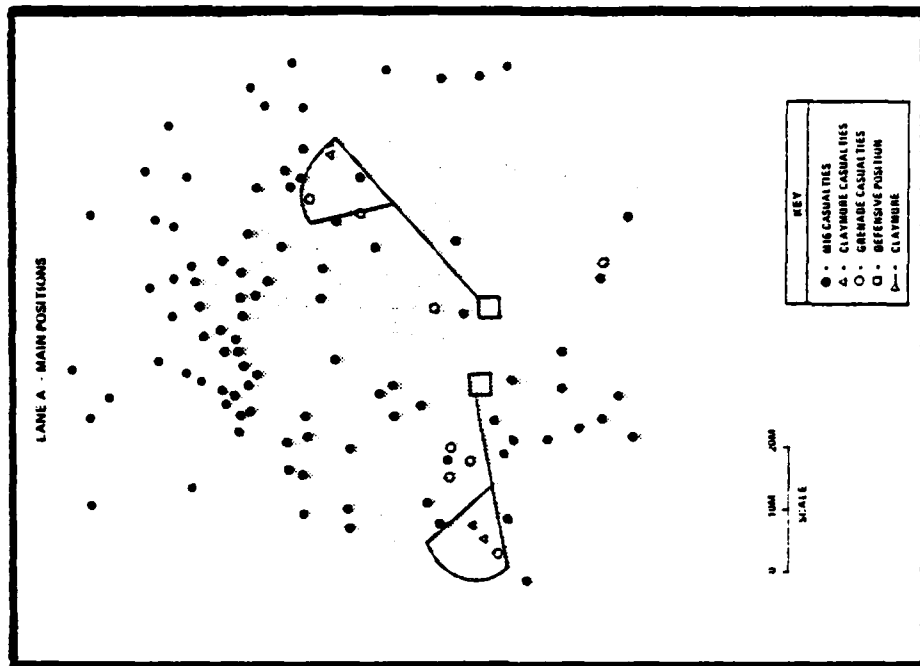
Figure 1. Lane A Predicted and Actual Location of Offense Casualties
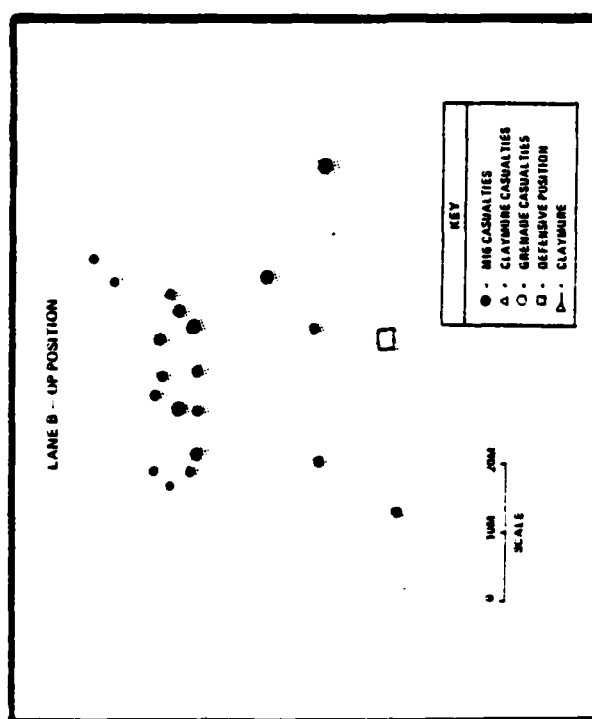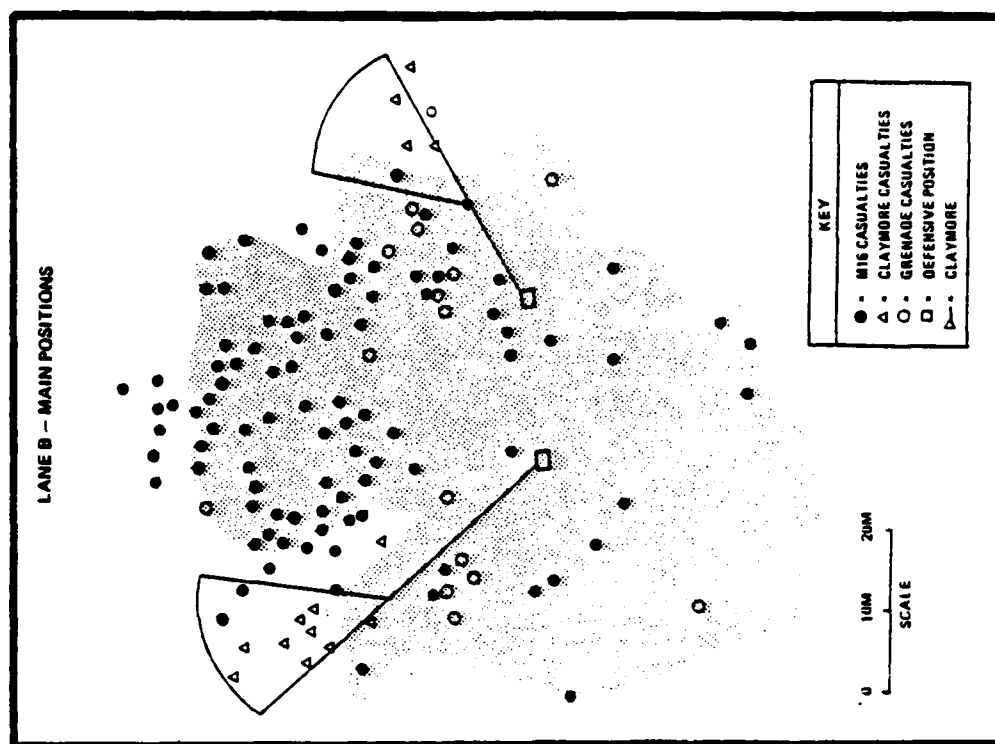
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Figure 2. Lane B Predicted and Actual Location of Offense Casualties

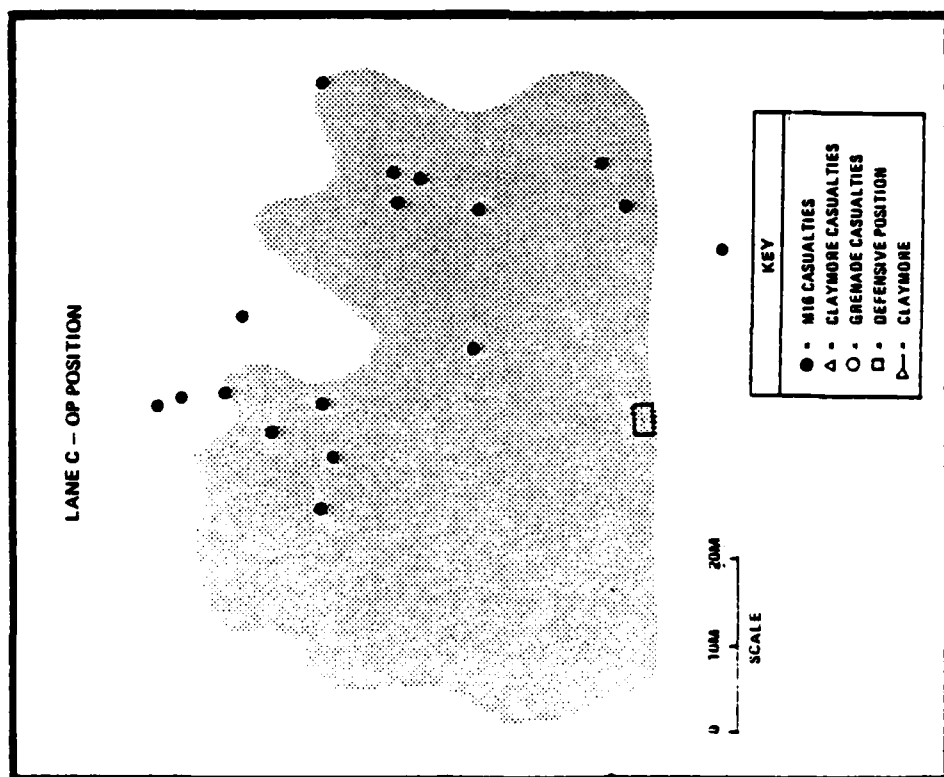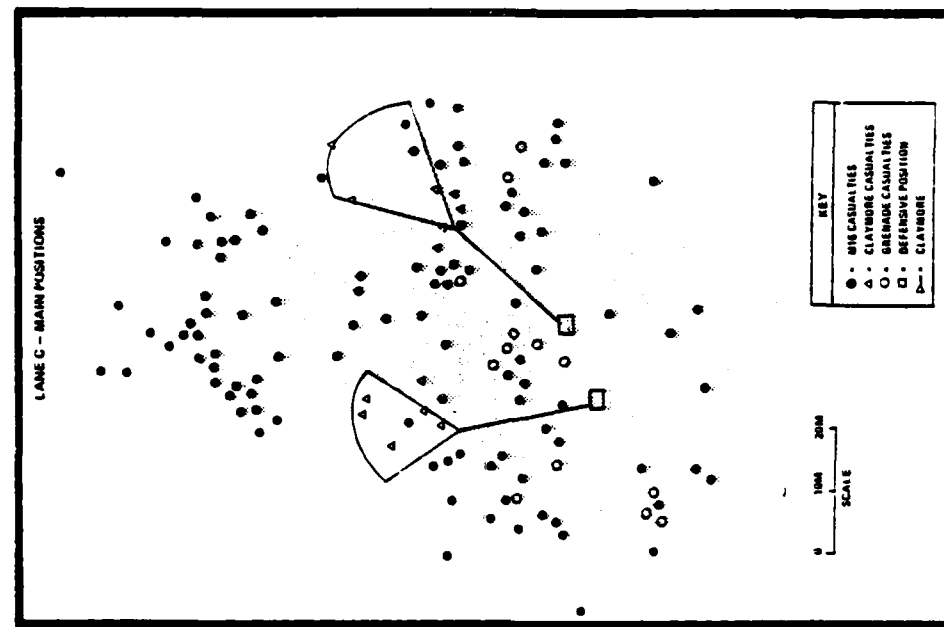Figure 3. Lane C Predicted and Actual Location of Offense Casualties

PREDICTING LOCATION OF CASUALTIES (LEFT AND RIGHT FLANK
MAIN POSITIONS)

In each lane, the main defensive position was comprised of right
and left flank positions, and casualty location predictions were made
for each. The accuracy of these predictions is summarized in Table 2.

Table 2

Location and Prediction of Casualties for
. Main Right and Left Flank Positions

| | Number of Casualties | | | | | | Percent Predicted | | |
| | Left Flank | | Right Flank | | Combined Positions | | | | |
Lane	Total	Zone[1]	Total	Zone[1]	Total	Zone[1]	Left Flank	Right Flank	Combined Position
A	26	25	79	54	105	79	96	68	75
B	85	63	40	32	125	95	74	80	76
C	23	5	105	85	128	90	22	81	70
Total	134	93	224	171	358	264	69	76	74

[1] Casualties within zone of prediction.

In one instance (Lane C), prediction accuracy for Total in
Table 2 does not agree with that for overall main position in Table 1.
This discrepancy exists because certain casualties occurred within the
overall main position zone of prediction (Table 1), but when the main
position zone was broken down into right and left flank zones, these
casualties were found to occur outside the prediction zones for the
individual positions. That is, casualties caused by the left flank
position occurred outside this position's zone but inside the right
flank position's zone, or vice versa.

Differences between lanes in accuracy of prediction for left flank positions were large, ranging from 22 to 96%. The overall accuracy of predictions for left flank positions (69%) however, was more in line with other predictions. There was far less variability in the accuracy of predictions for right flank positions, which averaged 76%. Overall, the accuracy of predictions was similar for the several lanes (A-75%, B-76%, and C-70%). The average of predictions for all lanes by position was 74%, which is consistent with all previously discussed predictions.
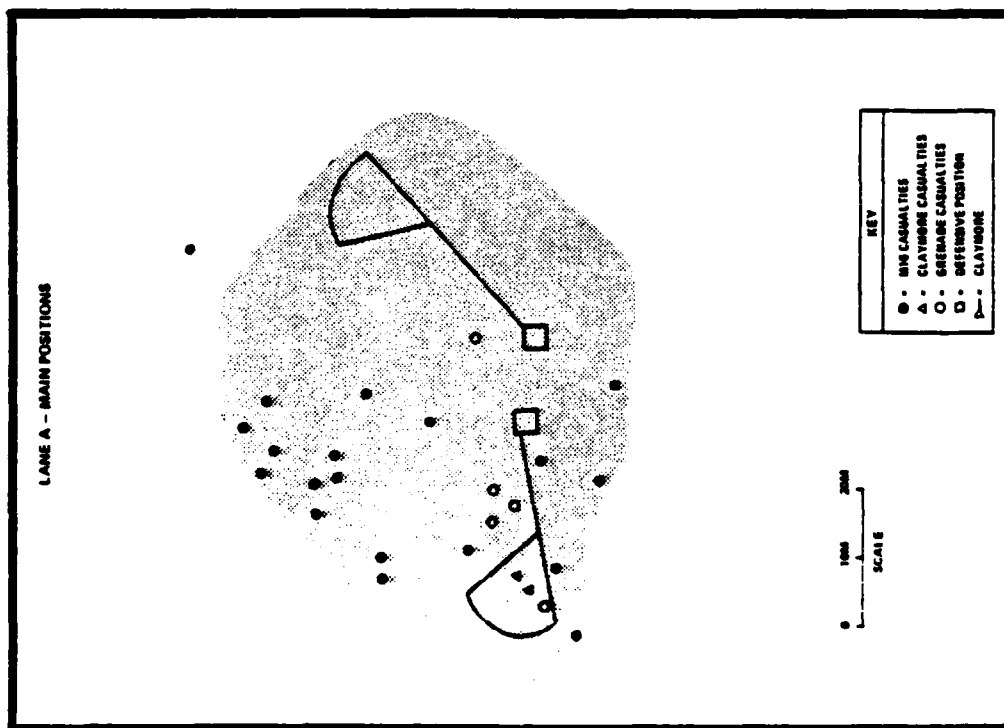
Figures 4 through 6 illustrate the predicted and actual location of offense casualties for each main defensive position on each lane. These figures are comprised of two diagrams, one showing the actual and predicted location of casualties for the left flank position, and one for the right flank position.

ENGAGEMENT RANGES

Having plotted the location of all casualties sustained by the movement to contact units and knowing the specific location of all defensive positions, it was possible to analyze engagement ranges. The engagement range data were analyzed and summarized in two ways. First, the mean engagement range by weapon, position and lane was determined. Second, the frequency of casualties caused by each weapon at different ranges forward of defensive positions was determined.

Table 3 shows the mean range of engagement for the three types of weapons employed by position and lane. No claymore mines were employed by the observation post (OP) positions. The soldier manning the OP position rarely employed grenades and was only successful in doing so on Lane A. Though the mean engagement range for hand

RIGHT FLANK POSITION

LEFT FLANK POSITION

LANE A — MAIN POSITIONS

LANE A — MAIN POSITIONS

KEY

● : M16 CASUALTIES
△ : CLAYMORE CASUALTIES
○ : GRENADE CASUALTIES
□ : DEFENSIVE POSITION
⊢ : CLAYMORE

SCALE

Figure 4. Lane A Predicted and Actual Location of Offense Casualties
by Denfensive Position

13

RIGHT FLANK POSITION

LANE B – MAIN POSITIONS

LEFT FLANK POSITION

LANE B – MAIN POSITIONS

KEY

- M16 CASUALTIES
- CLAYMORE CASUALTIES
- GRENADE CASUALTIES
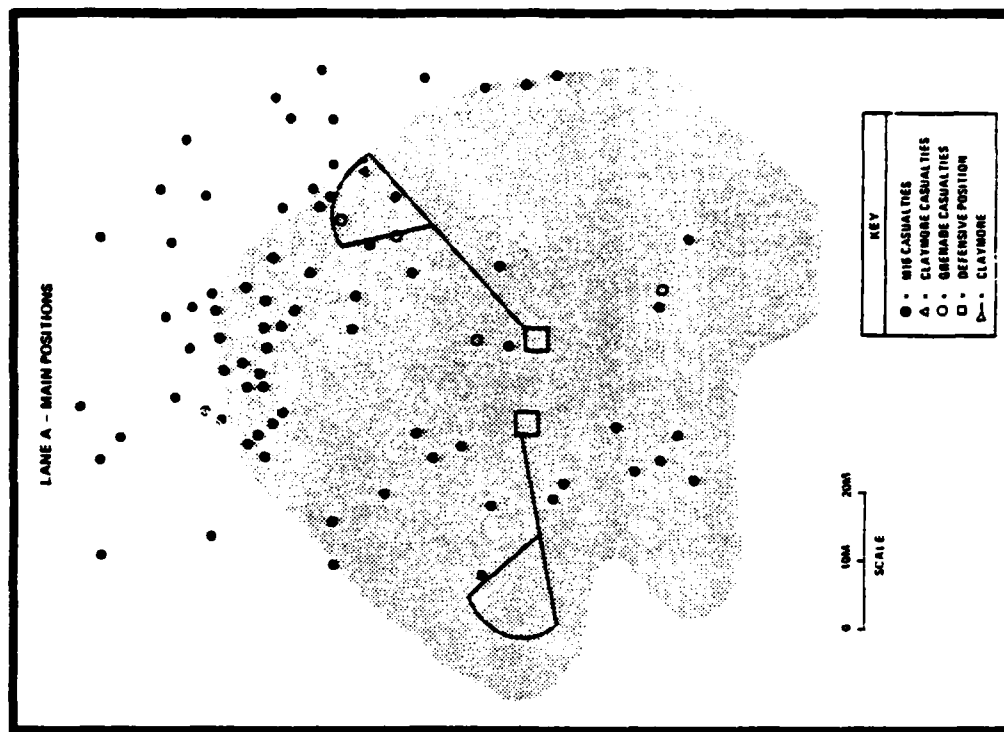- DEFENSIVE POSITION
- CLAYMORE

SCALE

0   10M   20M
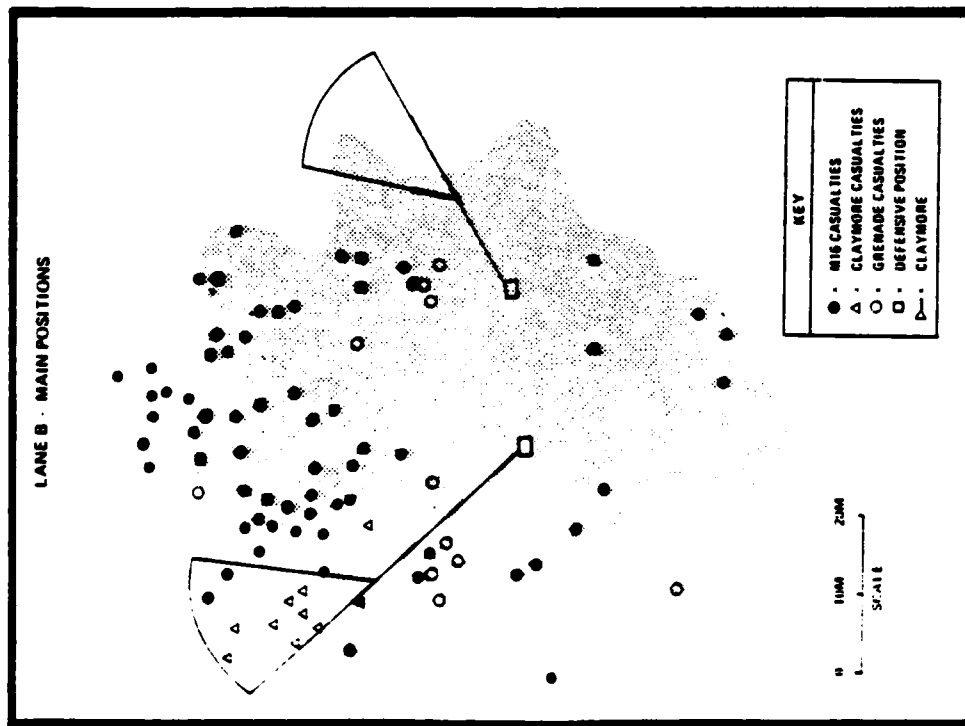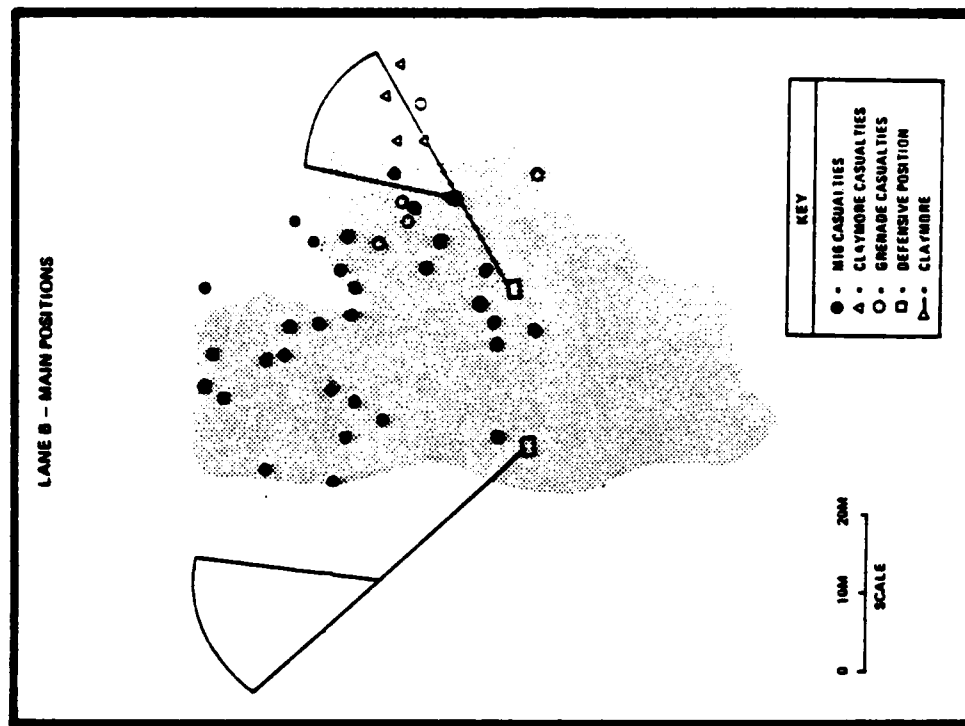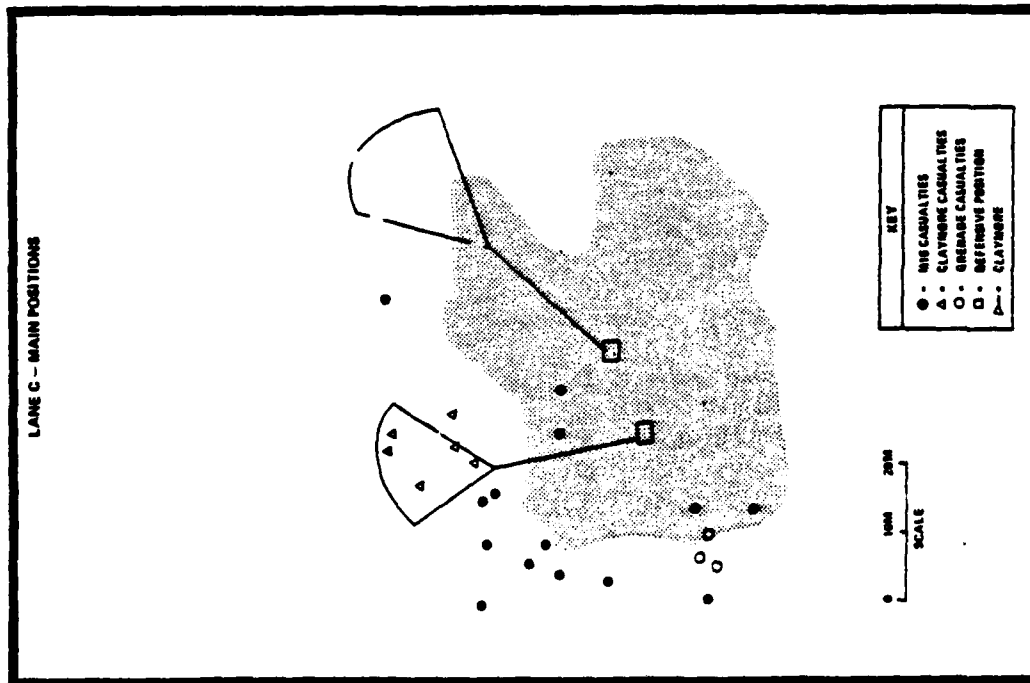
Figure 5.   Lane B Predicted and Actual Location of Offense Casualties by Defensive Position

14

RIGHT FLANK POSITION
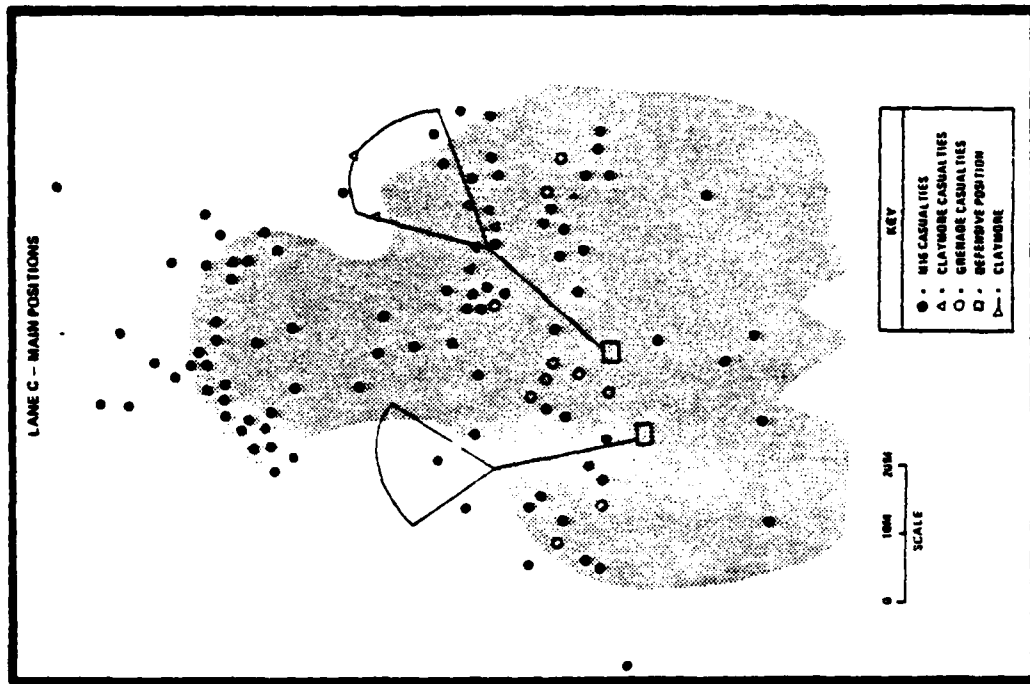
LEFT FLANK POSITION

Figure 6. Lane C Predicted and Actual Location of Offense Casualties
by Defensive Position

15

grenades and claymore mines was comparable for the one- and two-man positions, a considerable difference exists between the two positions' mean range for rifle engagements. Comparing the one- and two-man positions for each lane, it is readily apparent that the mean range for rifle engagements is considerably greater for the two-man position.

Table 3

Mean Engagement Range (Meters) by
Position, Lane and Weapon

Position	Lane	Weapon		
		Rifle	Hand Grenade	Claymore Mine
Observation Post	A	34.0M	27.5M	N/A
	B	24.5M	None	N/A
	C	37.1M	None	N/A
One-Man Position	A	25.0M	14.4M	23.5M
	B	22.0M	18.0M	26.3M
	C	26.0M	19.0M	29.5M
Two-Man Position	A	39.4M	22.5M	35.0M
	B	30.5M	22.0M	34.1M
	C	38.8M	16.8M	30.7M

The employment of the three weapons by range and frequency is illustrated in Figure 7. The rifle was clearly the primary weapon producing casualties (approximately 84%). The hand grenade produced approximately 10% of the casualties, and the claymore mine the remaining 6%.

Although rifle casualties were produced at all ranges, the greatest frequency fell between 31 and 40 meters from the defending

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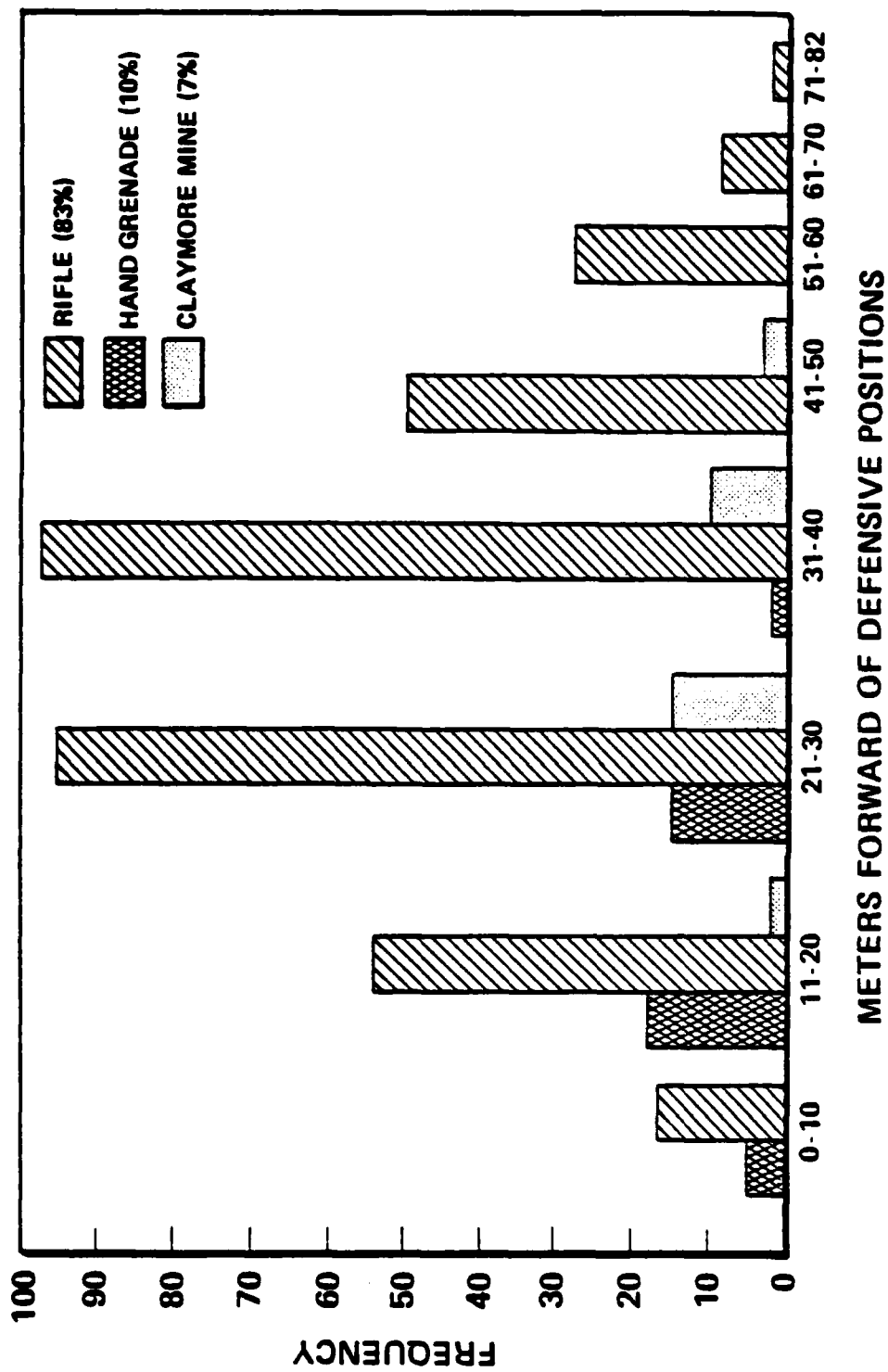
Figure 7. Frequency of Casualties Caused by Weapon Category at Different Ranges Forward of Defensive Positions

position. On the other hand, the grenade casualties tended to be much closer with the highest frequency in the 11 to 20 meter range. Claymore casualties did not occur inside 20 meters primarily due to their positioning by defense personnel and the fact that claymores were positioned at the same location during each exercise. The bulk of the claymore casualties took place in the 21 to 30 meter range.

DISCUSSION

Several conclusions to be drawn from this research are summarized as follows. First, a sound methodology for plotting the location of casualties as they occur during an engagement simulation MILES (Multiple Integrated Laser Engagement System) exercise was developed and successfully demonstrated. Second, a set of terrain indices were developed and used as a basis for predicting the location of offense casualties with consistent accuracy (74-76%). Finally, the ability to accurately plot the location of casualties, accurately predict the location of casualties, as well as the impact of the aforementioned on tools and techniques for providing diagnostic feedback, unit performance evaluation, and forecasting unit performance should be explored in greater detail.

PLOTTING CASUALTIES

Accuracy and completeness of information are critical when engagement simulation MILES exercises are used for evaluation purposes, as was the case at Fort A.P. Hill, where squad and platoon ARTEPs were conducted within the context of such exercises. When unit evaluations are based on such exercises, it is imperative that the data upon which evaluations are made are <u>consistently</u> accurate and complete. Reliance upon the recall of exercise participants (combatants and controllers/evaluators) who have just emerged from a confusing, loud, psychologically stressful, and physically demanding "simulated battle" for accurate and complete information regarding

their experiences is questionable when evaluation is the purpose. Despite its weaknesses, however, this approach has been applied in most engagement simulation exercises used for evaluation.

The requirement for accurate/complete exercise location data has already been recognized by the Army and is exemplified by the National Training Center (NTC), where considerable effort and expense have been dedicated to capturing, through instrumentation, accurate/complete exercise location data as it occurs. Unfortunately, such a system will probably not be available to individual unit training areas anytime in the foreseeable future. The casualty-plotting system discussed in this report is a feasible alternative method to the costly, complex NTC system..

Establishing a numerical, grid-marking system on each of the lanes used and corresponding scale maps (1 inch = 10 meters), during this research, proved to be an extremely accurate (i.e., casualties were plotted as they occurred) casualty plotting system. Casualty plotting interfered little with the conduct of the exercise and distracted minimally from the fidelity of the exercises.

Because the casualties were plotted during the course of the exercise, the rough casualty plotting maps were used to prepare a rough scale map (drawn oversized on a chalk board located on each lane) which was used and proved a valuable asset to the conduct of after action reviews (AARs) which occurred immediately following each exercise. The immediate availability, accuracy and completeness of this information added credibility to the individual conducting the ARR (as well as the AAR itself) and served to facilitate participants' efforts to reconstruct the events which took place during the

20

exercise. Given this, it is obvious that the techniques used to plot casualties during this research effort could prove valuable in overcoming many of the inherent weaknesses associated with the Army's current approach to conducting AARs.

Because of the resources required to implement the casualty plotting system described, it is not being suggested that such a system necessarily be employed during engagement simulation training. However, its use in conjunction with engagement simulation ARTEPs, or other types of evaluation, warrants further consideration of the required resource. The unavoidable necessity for accurate and complete data for evaluative purposes cannot be overlooked.

PREDICTING LOCATION OF CASUALTIES AND ITS RELEVANCE TO UNIT PERFORMANCE

Capability for forecasting the location of casualties is also important for unit evaluation. Over the years, evaluation of small tactical units has evolved considerably—from ORTs, to ATTs, to the current ARTEPs. For the most part, such evaluations have been in terms of qualitative judgments of overall performance. To some extent, qualitative judgment was used because there was no standard, accurate, or realistic manner in which to assess weapons effects. The assessment of weapons effects is important to evaluation of small tactical units because they are principal determinants of the units' effectiveness in relation to an opponent and, equally important, the the opponent's effectiveness in relation to the unit being evaluated.

With the advent of engagement simulation (SCOPES, REALTRAIN and, currently, MILES), it became possible to accurately and realistically simulate weapons effects in a standardized manner. This, however,

21

presented another problem. Where weapon effects can be simulated realistically, what should be used as criteria, or standards, of unit effectiveness? One approach has been to forecast battle outcomes based upon a priori estimates of the potential capabilities of a unit and its opponent, taking mission and other contributing variables into account. This approach as well as most considers product as opposed to process measurement.

A more specific, quantitative method which might be applied to unit evaluation that considers processes more than products involves predicting the location of casualties. These predictions could be based upon the indices previously discussed in this report. Since these indices are based upon common military principles such as weapon firing zones, cover and concealment, routes of advance, and dead space, it seems reasonable that predicting location of casualties could be overlayed or integrated into a process evaluation schema. For example, if an unit were given a defensive mission on a specific piece of terrain, the defensibility of the terrain could be established using terrain indices. This would involve identifying the best manner in which to defend the terrain, the locations of positions, firing zones and, based upon the aforementioned, predicting the location of offense casualties for a good, fair, and poor defense. Predictions would then serve as process standards against which a unit could be evaluated.

The feasibility of predicting the location of casualties has been demonstrated in this research. When the terrain indices described herein were used, the location of offense casualties were predicted with an accuracy of approximately 76%. Furthermore, despite some

t14errain differences between lanes, predictive accuracy was consistent across lanes, demonstrating that the method can be adapted to lane difference and, thus, that it should have general application.

A satisfactory method has been developed to predict casualty location during engagement simulation exercises. However, it may be possible to improve the accuracy of the method in the future by eliminating or reducing the effects the problems encountered in the current research. The method may now be employed prior to engagement simulation exercises to evaluate defensive position selection, claymore mine placement, and routes of advance.

If during further research these methods prove to be valid in judging successful processes, a significant contribution will be made to the evaluation methodology of engagement simulation. Tactical units will be able to receive detailed diagnostic feedback on their methods of employing terrain in simulated combat.

MEAN ENGAGEMENT RANGES AND ITS RELEVANCE TO UNIT
PERFORMANCE

As was the case with predicting casualty locations, data pertaining to mean engagement ranges by specific weapon systems could be overlayed or integrated into a process evaluation schema. Such measurements could be applied to the processes involved with determining firing zones/selecting defensive position locations, effectiveness/use of cover/concealment and selecting routes of advance.

The feasibility of collecting the data required to calculate mean engagement ranges by weapon system has been demonstrated in this research. The method used to collect the required data should have

general applications including armor and combined arms engagement simulation scenarios.

Though further research is required before it can be stated conclusively, it is felt that mean engagement data can make a significant contribution to combat unit performance evaluations.